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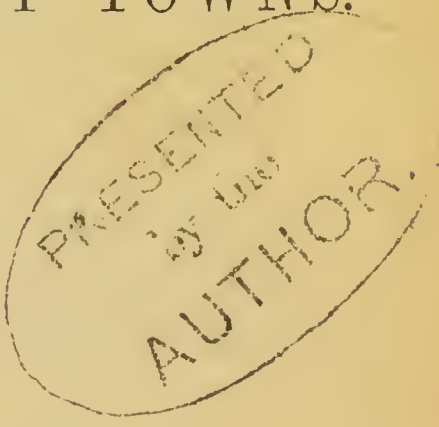

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PREFACE.

A Committee of the House of Commons having been appointed, during the past session, to inquire into the subject treated of in the following pages, it may be considered presumptuous in a private individual to anticipate its labours and its conclusions. The truth is, however, the Committee has separated without coming to any definite conclusion or practical result, having merely drawn up the following Resolutions:—

1. That careful and exact experiments are necessary to elucidate the agricultural value of sewage, and the best mode of applying it.

2. That such experiments have been carried on at Rugby by the Commission appointed to inquire into the best mode of distributing the sewage of towns, and applying it to beneficial and profitable uses.

3. That it is desirable that these experiments shall be continued during the present year.

If these particular experiments have not, in the opinion of the Committee, been conducted for a sufficient length of time to enable them to draw

accurate conclusions on the subject; sewage water has been employed, in other instances, for so many years, that we possess as much information as is probably necessary respecting its beneficial results. What advantage, therefore, is to be derived by postponing the question for another year, I am at a loss to understand. It is only putting off unnecessarily, not the evil day, but the advent of a new and more prosperous agricultural epoch.

In addition to this, the inquiries of the Committee, on one particular point, the revenue that may be, and ought to be, derived from the sale of the sewage—the principal object for the appointment of the Committee—appear to me to be directed in the wrong channel. On the only two occasions when I was present, the whole time of the Committee was occupied in ascertaining the result of the analysis of sewage water, and with calculations of the value of the ingredients found therein. Taking the results thus obtained, a valuation was then made of the whole sewage of London; Dr. Hoffman stating that the total annual value was 1,444,171*l.*—a sum greatly below its actual value, as will be hereafter shown. Now sewage, it should be remembered, is only one mode of obtaining the fertilizing ingredients contained in the *excreta* of man; and that mode confined almost exclusively to England, and to certain towns in England.

Then, again, it is extremely difficult to draw any

general deductions from the analysis of sewage water; the result being not only different at each season of the year, but in each locality, and even in the same sewer, at different hours of the day. The quantity of ammonia, for instance, found in sewage water, has varied from *one* grain and a-half to thirty-seven grains in the gallon!

The proper course to pursue, in my opinion, is to ascertain, first, what is the value of the *excreta* of man, in an agricultural point of view; and then to inquire, what are the results of the application of sewage water to land. Should the practical results be different to the theoretical calculations, we may then be certain that the difference is to be ascribed, either to the loss of the fertilizing ingredients, or, else, to some change that the latter undergo, when thus largely diluted with water. It will then become a proper subject of inquiry to ascertain the cause of the loss of the fertilizing matter, or of the change in its properties. This is the course that has been pursued on the present occasion. There is, also, another point of view in which the subject has been regarded by me, and this is a social one—a subject not entered into by the Committee, or falling, possibly, within the scope of their inquiries.

In addition to these reasons, sufficiently interesting and important at all times, there is another, which has induced me to bring the subject forward

at the present moment—this is, the distress in the cotton districts. And what, it will doubtless be asked by many persons, has the cotton famine to do with the utilisation of the sewage? There is no bread famine or actual dearth of provisions at the present moment in England! Thank God, there is not; but then we have what is nearly the same thing to the distressed operatives—a dearth of labour. The question therefore arises, whether the opening up of a new source of wealth would not supply, to a certain extent, this want? That such might be the case, it will be my object to show hereafter, in the concluding remarks.

THE UTILISATION OF THE SEWAGE OF TOWNS.

It may, perhaps, be considered by some persons that the present is not a very pleasant, or a very delicate, subject to discuss; but a cursory consideration of it must convince every one that this is an erroneous impression, and an unfounded prejudice. To the man of science, and even to the ordinary contemplator of nature's operations, all substances are alike, and every process equally important; for he finds that what is repulsive and offensive to-day, may be changed to-morrow into forms of beauty and usefulness. The decay of one body becomes, in fact, the cause of life to another; thus proving to us, by other than Holy Writ, that death itself is not the destruction, but only the transformation of the elements of which our bodies are composed, for not an atom will, or can, be lost.

In the same way we find, in the vegetable kingdom, that the processes of decay and putrefaction are necessary for the life and growth of plants; without the elements then produced, flowers would not blossom, fruit and grains could not be formed. Not only, therefore, is the putrefaction of organic matter thus necessary, for the growth and health of plants, but the elements then formed are equally necessary to man; for without plants neither he, nor the animals on which he partly depends for food, could subsist. These processes, however, are offensive to our senses, and repulsive to our olfactory organs.

To those who have not reflected on the subject, it may appear strange that the very elements of our existence, or, at least, some of them, should thus be derived from corrupt and putrefactive matter. But we shall find, on a further investigation of the subject, that in this, as well as in all other instances, everything has been ordered for some great and special end. The odour which arises during the process of putrefaction, and which is so offensive to our olfactory organs, is merely a warning, an inducement to us, to place that matter beyond the reach of our senses, by burying it in the ground. This is what instinct and reason both equally point out. Instead of following this course, we allow all kinds of decomposing matter to rot on the surface, or, what is still worse, we throw this

matter into the rivers and the sea, rendering their waters offensive to the taste and the senses of man, and to the finny race; while many species of the latter would seem to be destroyed, by the admixture of sewage with river and sea water. That all decomposing matter should be buried in the soil, and not be thrown into the rivers or the sea, it will now be my object to show.

The plants taken away from the land, to furnish food for the animal creation, contain, independently of a variety of inorganic substances, two elements belonging to the organic kingdom, on which they principally depend for nourishment. These are carbon and nitrogen. The former is derived partly from the soil, and partly from the atmosphere, but principally from the latter source, where it exists in the form of carbonic acid gas. In this state it is absorbed by the leaves, and becomes decomposed—the oxygen being liberated, and the carbon being retained and assimilated. The other substance, or nitrogen, is also contained both in the atmosphere and in the soil, but more particularly in the latter. As the putrefaction of animal bodies is going on constantly on the surface of the earth, and as one of the products of this process is ammonia, a compound of nitrogen, it necessarily, being a very volatile substance, becomes diffused in the surrounding atmosphere. Having a great affinity for water, it is rapidly and completely absorbed by the aqueous

vapour always existing in the air, but again descends to the earth when the vapour becomes condensed, and falls in the form of rain. It is from this source that plants, growing on soils not manured, derive their nitrogen; and for those plants which contain only a small quantity of this substance, the supply thence derived is sufficient. There are others, however, such as all the varieties of corn, that require a large supply of nitrogen; and it is found in practice, that the soils in which such plants grow soon become exhausted, unless they are manured, or unless the crop be changed. The cause is sufficiently apparent. In 800lbs. of wheat, there are 16lbs. of nitrogen. As there are generally 4 quarters grown on an acre of land, there will be taken away with the crop, every year, 38lbs. of nitrogen from each acre of corn land. This is much too large a quantity to be derived solely from the atmosphere, as experience shows.* Unless, therefore, we return this quantity to the soil, or, at least, the excess of that furnished by rain water,

* Baron Liebig, speaking of the tracts of land in America on which the early colonists settled, but to which they failed to add any manure, remarks,—"We all know what has become of these fields. In less than two generations, though originally so teeming with fertility, they were turned into deserts, and in many districts brought to a state of such absolute exhaustion, that even now, after having lain fallow more than 100 years, they will not yield a remunerative crop of a cereal plant."—*Modern Agriculture*, p. 243.

such land will be unfitted for the growth of corn; or, if grown, the crops will be deficient in nitrogen. They cannot, therefore, have the requisite and ordinary proportion of gluten, which is a compound of nitrogen, and forms the nutritious part of wheat. That the quantity of gluten varies greatly, according to local circumstances, or the nature of the soil, we know from experience and direct experiment. This is shown in the following table.

TABLE A.

Quantity of Gluten contained in different varieties of Wheat.

Varieties.	Authorities.	Per Cent.
French Wheat . . .	Prout	13·5
Ditto Alsace . . .	Boussingault . .	17·3
Barbary Wheat . .	Davey	19
Sicilian ditto . . .	„	21
English ditto . . .	„	24
French ditto . . . (jardin des Plantes)	Boussingault . .	33

That this variation, in the quantity of gluten, is to be ascribed to the greater or less quantity of ammonia furnished by the soil, or by the manures applied to it, will be evident by a reference to the next table.

TABLE B.

Quantity of Gluten contained in Wheat grown on Soils to which the following manures had been added.

Manure.	Gluten.	Starch.	Bran.	Total.
Human Urine. .	35·1	39·3	25·6	100 parts.
Bullock's Blood .	34·2	41.3	25·5	100 „
Night Soil . . .	33·1	41·4	25·5	100 „
Horse Dung . .	13·7	61·6	24·7	100 „
Cow Dung . . .	11·95	62·34	25·71	100 „

A pound of wheat, therefore, raised from land manured with human urine, would contain nearly three times as much gluten as that raised from land manured with horse-dung. In the latter case, the deficiency in gluten is replaced by starch, which, although useful and necessary for the health of the body, does not contribute, excepting in a slight degree, to the strength of the individual. This is easily demonstrated.

The two principal organic substances taken into the stomach, in the form of food, are carbon and nitrogen, the former being always in the largest proportion. Carbon is one of the ingredients of the soft parts of the body, and it contributes to the formation of fat, which is a compound of carbon and hydrogen, the latter being in a small proportion only.

The chief use of carbon is to keep up the process of respiration, and to support the animal temperature. By uniting with the oxygen taken into the lungs, during the act of respiration, heat is evolved; the same as during the combustion of coal and other carbonaceous substances out of the body. But although these functions are necessary for the health and life of the individual, they contribute only in a slight degree, and indirectly, to the strength of the body. This is due to the nitrogen contained in the food. When deprived of this elementary substance, the fibrin of the blood will be diminished in quantity, the muscles of the body will become flaccid, and the heart and blood-vessels lose their power, and become attenuated. As a consequence, the circulation languishes and death ensues, unless some form of food be administered containing large proportions of nitrogen.* We thus find how necessary it is that man should employ nitrogenized articles of food, and that these should contain the proper proportion of this element. This is more particularly true with respect to wheat

* Those accustomed to the management of horses will readily understand the difference between a nitrogenized and a non-nitrogenized diet. When a horse is first brought up from grass, —feeding on an article containing but a small quantity of nitrogen—his muscles are flabby and weak, and he is unfitted for work. When fed on corn, however, he soon recovers his strength, and his muscles become firm and hard. There is also

and other corn crops, on which the labouring classes depend for sustenance, more than on meat, the most highly nitrogenized substance of any. Liebig has, in fact, gone so far as to ascribe the downfall of empires to this circumstance alone—the exhaustion of the soil, and the non-renewal of its fertilizing properties by manures containing the requisite proportions of nitrogen. I am not prepared to subscribe entirely to the conclusion of the celebrated German chemist; but there can be no doubt that a nation, living upon articles not sufficiently azotized, will be wanting in physical energy. We observe this with the Hindoos, who subsist principally upon rice—the least nitrogenized of the cereal crops. We also find that the descendants of those colonists who settle on new lands or virgin soils, become a stronger and more athletic race than their progenitors. We have observed this in North America, notwithstanding that the climate there is much more unhealthy than in England. Hence the necessity of returning to the land the nitrogen taken from it. That this is not done in England, notwithstanding the quantity of manures employed,

a difference in the kind of corn given to him. When a handful of beans—one of the most highly nitrogenized of the cereal crops—is added to his oats, he will be able to perform a greater amount of labour than before, and with more spirit and alacrity. Hence the addition of this article to the diet of sluggish horses, or of those that work hard.

will be shown hereafter. Whether we are to refer the evident deterioration of the race of Englishmen, more particularly in the manufacturing districts, to this cause, is a question well worthy of consideration. My own opinion is, that this is one of the causes, if not the principal one; for the nature of the employment of these men alone will hardly account for this deterioration.*

Sergeant Farrell, recruiting sergeant, stated to Dr. Playfair that, where he could get eighteen recruits formerly in Lancashire, he can only obtain *one* now, and that one is frequently rejected. At the head recruiting office in Lancashire, the total number of recruits sent up between Jan. 1 and Oct. 31, 1843, chiefly from Lancashire, Cheshire,

* There are other causes which produce the same results in the present day; such as the use of gin and tea—the one being but too frequently the adjunct or consequence of the other. Although differing in other respects—the one being a stimulant and the other a narcotic—they both produce the same result with the labouring classes: the substitution of a non-nutritious for a nutritious article. With the rich, who take a proper quantity of solid food, and a stimulus, in the shape of wine, at the same time, tea may be a harmless and even a salutary beverage, by allaying the excitement produced by the former; but to the poor man, who uses tea as *a substitute* for more solid food—and I have frequently seen a labouring man sitting down *to a dinner, or supper*, of tea and bread and butter, being unable to purchase the luxury and the substantial at the same time—such a beverage is little better than a poison!

and parts of Shropshire, Derby, North Wales, and Staffordshire, was 1,560. Of these, 876 were approved, and 684 rejected. In Liverpool, during the same period, 930 presented themselves for examination, and 439, or 47 per cent., were rejected.* But, whatever conclusion we may draw on the subject of this deterioration, one thing, at least, is certain: if the corn crops do not contain the proper proportion of gluten, they will be deficient in nourishment; while, if the requisite quantity of nitrogen be not furnished to the soil, the plants will be weak, and the grain small.

This is a truth that mankind has been cognizant of for ages; and it is to supply this deficiency that manures have been resorted to. In general, these manures have been composed of the dung of domestic animals, as the cow, the ox, the sheep and the horse, and, occasionally, of the *excreta* of man. The *rationale* of the operation is this:—All the substances that pass into the bodies of animals, in the form of food, are expelled, sooner or later, and without any loss, by the secretions and excretions. The textures of which our bodies are composed are in a state of constant transformation; the particles of which they are formed being taken away by one set of vessels—the absorbents—and replaced by another set—the arteries. There is thus a regular and constant discharge of old matter, and as regular

* "Statistical Journal," March, 1861.

a supply of new materials. This supply, so necessary to animal existence, is derived from the food taken into the stomach; but the effete or worn-out particles are expelled from the system by the different secretions and excretions, and more particularly with the urine and the fæces. Hence we should expect to find that all the elements taken from the soil, in the form of food, would be again restored, if the *excreta* of the animals using it be added to the land. Such has been shown, by direct experiment, to be the case; and it is on these facts that the theory of manures is founded. These results are very satisfactorily shown in the table now added, and drawn up by Dr. Angus Smith.

TABLE C.

Quantity of Nitrogen, &c., taken from the Soil, and furnished by the Excreta of Man.

Elements removed by a four course system, from 100 acres.		Ditto, consumed by 100 adults.	Ditto, supplied by the Excretions.
	lbs.	lbs.	lbs.
Nitrogen	2,681*	2,317	2,312†
Lime and magnesia .	948	3,158	3,158
Phosphoric acid . .	1,549	1,713	1,713
Potass and soda . .	780	827	827
Silica	450	166	166
Metallic oxides . . .	8	6	6
Sulphur and chlorine .	21	87	87

* Per acre, 26·81. † Per man, 23·12 yearly.

Although the *excreta* of domestic animals are usually employed as manures, it is to be remembered that these can only return what they have taken away from the soil—not a particle more. They can only fertilize, therefore, the same number of acres as those on which they fed, and, properly speaking, the same land; for the *excreta* of animals not only differ from those of man, but from each other, more particularly in the quantity of nitrogen contained therein. This will be evident by a reference to the following table.

TABLE D.

Quantity of Urea contained in* 1,000 *parts of Urine.*

Man	32·91	† In herbivorous animals, there is, in addition, hippuric acid, which, during the process of putrefaction, is converted into benzoic acid and ammonia.
The Ox †	19·76	
Horse	12·44	
Pig	4·9	
Goat	3·7	

* Nitrogen exists in the urine principally in the form of Urea, a compound of carbon, hydrogen, oxygen, and nitrogen; the latter in the proportion of 46·67 per cent.

You can, it is true, substitute other land, and raise other crops—as corn, for instance; but then you must, by so doing, impoverish the grass lands on which the animals fed; while, as the matter, which is thus given to the soil, is not the same as that which was taken away—if the produce was wheat,

and consumed, as a matter of course, by man—the crop will be deficient both in quantity and quality. The difference in quantity is shown by the following table; while that of quality will be evident by a reference to a previous Table (B).

TABLE E.

*Table showing the Result of Experiments with different Manures.**

	Quantity produced in proportion to seed.
No manure	3 times.
Herbage, grass, &c.	5 „
Cow dung	7 „
Pigeon's dung	9 „
Human urine	12 „
Human manure and bullock's blood . .	14 „

* By Professors Hemstadt and Schübler.

This is what we should have expected, *à priori*, for the food of animals not only differs from that of man, but from that of each other—carnivorous animals making use of a more highly nitrogenized diet than herbivorous ones. It is for this reason that guano, which is composed of the *excreta* of wild sea-fowl living on fish, has been so extensively employed of late, and since its discovery, as a dressing to wheat and other corn crops. But this manure is not only an expensive one, its supply

also is limited, while it will ere long, in twenty years or so, become entirely exhausted. It is time, therefore, to look for another and more permanent supply, and there can be no better one than the *excreta* of man. Referring to the quantity of guano and bones imported into England, Baron Liebig observes: "Yet all this mass of manure is not worth mentioning, when compared to the arable surface of Great Britain, and is but a drop, when compared to the sea of human excrement carried by the rivers to the ocean."* Not only is this manure more easily obtained than any other, and its supply constant and abundant, but it is richer in fertilizing properties.† More than this, it will restore to the land exactly that which has been taken away in the food consumed by the inhabitants of the country. If, also, the *excreta* of the animals nourished on the same land be added to the soil, all the elements that have been removed by the crops will thus be restored, and the land can never become exhausted. The question therefore natu-

* "Modern Agriculture," p. 232.

† "Animal manure," as Liebig has justly remarked, "not only supplies plants with a certain amount of their mineral and atmospheric food, but also with carbonic acid and ammonia—substances that are indispensable for the introduction into the vegetable organism of the mineral constituents, which are insoluble in water. The phosphates of lime and of magnesia, as well as silica and the earthy carbonates, are rendered soluble by the presence of ammonia and carbonic acid."

rally arises, whether the *excreta* of our population, and the sewage of our towns, cannot be generally employed, not only as a substitute for guano, but at times and under circumstances when the latter would be too expensive or difficult of attainment. That the former can be invariably obtained there is no doubt, while its employment would be attended with advantages not to be attained in any other way, or by any other manure. These I shall now endeavour to point out.

In the first place, there would be sufficient manure, not only for all the corn land at present under cultivation in Great Britain, but, also, for as many acres as are required to produce the corn annually imported into the United Kingdom. As nitrogen is the substance principally required for corn crops, and as this is almost entirely contained in the urine, I shall first consider what would be the result of the employment of the liquid manure alone.

Each individual passes, on the average, two and a-half pounds (two pints) of urine daily, and 912 lbs. in the course of the year.* As this liquid contains 3 per cent. of nitrogen, according to Baron Liebig and other chemists, each individual would thus furnish 27·36 lbs. of nitrogen in the

* This proportion is greater than that stated by many writers. Dr. Charles Robin however, the best authority on the subject perhaps, states that the daily average is 1,282 grammes=2½ lbs. avoirdupois.

course of the year. Now 3 cwt. of guano is always considered sufficient for an acre of corn land; and as this manure contains, on the average, about 8 per cent. of nitrogen, the above quantity would give twenty-seven pounds. If applied in the same proportion, each individual would be able to fertilize an acre of *corn* land. The *excreta* of twenty-eight millions—the present population of Great Britain—would therefore furnish sufficient manure for 28,000,000 acres. These facts will be more clearly perceived by a reference to the following table:—

TABLE F.

Showing the Number of Acres that the undermentioned Individuals would fertilize annually, Guano being the standard of comparison.

Supply.	Quantity.	Proportion of Nitrogen.	Number of Acres.
Guano. . . .	3 cwt.	27 lbs.	1
Urine, for 1 individual .	912 lbs.	27·36 lbs.	„
Guano. . . .	15,000 tons	1,205 tons	100,000
Urine, for 100,000 persons	40,714 „	1,221 „	„
Guano. . . .	450,000 „	36,150 „	3,000,000
Urine, for 3,000,000 persons	1,221,420 „	36,630 „	„
Guano. . . .	4,200,000 „	337,400 „	28,000,000
Urine, for 28,000,000 persons	11,399,920 „	341,880 „	„

The exact number of acres under corn cultivation, in this country, is unknown; but it was calculated, in 1851, that there were 12,234,150 in the United Kingdom. Deducting these, there would remain 15,765,850 acres capable of being manured from this source. If sown with corn, they would produce 78,829,250 quarters, reckoning five quarters to the acre, which we may fairly do, as the produce is even more than this, when human manure is employed. It is not probable, however, that we could obtain this additional quantity of land, as there are only 18,000,000 acres uncultivated in the United Kingdom. The following table shows the proportion of cultivated and uncultivated land, as calculated by different writers, in 1851.

TABLE G.

Showing the Quantity of Cultivated and Uncultivated Land in Great Britain (1851).

	Corn.	Roots, Clover, &c.	Pasture.	Uncultivated.	Total.
	Acres.	Acres.	Acres.	Acres.	Acres.
England	7,972,500	5,327,500	17,000,000	6,507,915	37,324,915
Scotland	1,430,621	1,584,951	11,031,890	6,000,000	20,047,462
Ireland	2,831,029	1,831,963	11,145,279	5,000,000	20,808,271
Total	12,234,150	8,744,414	39,177,169	18,024,915	78,180,648

All that we could hope for, perhaps, would be to grow sufficient for our own consumption. But this

would be a great gain, for last year we imported 20,000,000 quarters of corn of the value of 34,000,000*l.** To grow this quantity of corn, 4,000,000 acres would be required, taking the average at five quarters per acre. There would then remain sufficient manure for 11,765,850 acres; and if this were applied to the grass lands, and to green crops, the increased produce might supply sufficient food to feed the cattle now imported from abroad, amounting to 20,000 head in the course of the week, or 1,000,000 in the year.†

Such are the advantages that would accrue to the nation at large, by the employment of that which we now throw into the rivers and the sea; rendering the water of the former unfit for the use of man, and causing both to be offensive, if not poisonous, to the finny race. Not only would there be a cheap loaf for all, and, what he so much requires, a cheap joint of meat for the hard-

* Mr. Cobden, in a recent letter to the Manchester Chamber of Commerce, remarked :—"One-third of the inhabitants of these islands—a number equal to the whole population of Great Britain at the commencement of this century—subsists on imported food." And he added:—"The grain of all kinds imported into England, in 1861, exceeded in value the whole amount of our imports sixty years ago."

† The increased produce, when sewage manure is applied to grass lands, is extraordinary. At Edinburgh, the grass on the meadows, irrigated with sewage manure, is sold by auction, and realizes from 30*l.* to 40*l.* every year.

working labourer, but it would then be unnecessary to send 10,000 miles for our manure, leaving so much gold in its place.

Were the agriculturists disposed to apply the requisite quantity of guano, and could they afford to pay for the same, the supply, it should be remembered, is limited. The average quantity of guano imported into this country is between 2,000,000 and 3,000,000 cwt.; but the quantity required annually, in order to obtain the same amount of ammonia as that contained in the *excreta* of the whole population of Great Britain, would be 84,000,000 cwt., or 4,200,000 tons. The cost of this manure, besides, would amount to 56,600,000*l.* annually.

This additional quantity of land might be taken entirely from that which is now uncultivated; or, partly from this, and partly from the pasture land. As there would be sufficient manure for 11,765,850 acres of pasture land, and as the produce, when thus treated, is greatly increased, half the land required for the additional quantity of corn might readily be taken from this source.*

* The tendency, at the present moment, is all the other way. Mr. Caird stated, in the House of Commons, that in Ireland, between 1849 and 1859, the extent of corn land had diminished one-fifth; while the number of live stock had, in the same period, increased one-half. And he added:—"He believed that, at this moment, we were experiencing a change of that description in this country (England)."

On the other hand, the whole might be obtained from the waste lands; for the poorest soils, when thus manured, are capable of growing corn. All, in fact, that corn crops require, under such circumstances, would be carbon, which is derived from the atmosphere, and silica, which can be obtained, in general, from the poorest soils.* While, therefore, we have so many million acres of land uncultivated, and a population like Great Britain, capable of affording so large a quantity of manure, it will be a disgrace on the science and energy of the age to be obliged to import a single quarter of corn, unless in years of scarcity.† In-

* In addition to carbon and nitrogen, plants contain oxygen and hydrogen; but these elements are derived from the air and from water, which, like carbonic acid, is decomposed by plants.

† Supposing that, everything else remaining the same, we were able to devote the above number of acres to wheat cultivation, and that all the *excreta* of our population were applied to them, it would be interesting to ascertain the actual value of the produce.

The Earl of Essex informs us, that he obtained fifty-three bushels of wheat, and five loads of straw, from an acre of land irrigated with sewage water. The value of this, calculating the wheat at 7*s.* a bushel—the average last year—and the straw at 30*s.* a load, would be 26*l.* For 28,000,000 acres the amount would be 728,000,000*l.*! Although such results may appear fabulous, and could not be obtained in England, they yet show the immense value of the *excreta* of man, for without such an addition the land could not grow corn.

dependently of these advantages, there are several others that would be obtained by the utilisation of the sewage of our towns. These I shall now proceed to consider.

In the first place, we require a larger relative proportion of food now than formerly.

This arises from the fact that we live in an epidemic period, when failure in the crops and its concomitant, famine, have always been experienced to a greater or less extent, as well as pestilence or disease in the animal creation; as was particularly apparent during the prevalence of the black death of the fourteenth century. The present period was inaugurated in India, in 1817, by the appearance of the epidemic cholera, which was a new disease—a *nova pestis*—for there is no record of such a disease having prevailed during historical periods; the epidemic cholera being as distinct from the endemic cholera of India, as it is from the bilious cholera of this country. In a work published by me in 1840, at a time when we had only experienced one visitation of the epidemic, I drew attention to this fact; and stated it to be my conviction, not only that this disease would return again and again, for a certain unknown and lengthened period, but that it would be accompanied and followed by the same series of phenomena as had been observed at all epidemic

periods.* This prediction has been verified to the letter; for not only has the epidemic, contrary to general expectation, returned on two occasions since, but we have had, in addition, murrain among the cattle, blight or disease in the potato and other crops, and an inversion of the seasons that has produced a partial, although not a total, failure of the corn crops.

The murrain of the present century—known by the name of pleuro-pneumonia—has been one of the most general and wide-spread, as well as fatal, of any on record. It first appeared in Europe in 1835, but did not reach this country until 1839, when it spread over England and Ireland, affecting principally the thin-skinned and delicate breeds—as the Devon. The sheep were attacked at the same time. The pigs, however, had been affected previously to this, in 1836, by a disease similar to cholera, and hence termed *morbus niger*. They were again attacked in 1842 with a similar disease. In 1843, there was malignant influenza among cattle; and pleuro-pneumonia, in 1844, among cattle, horses and pigs. Murrain appeared again in 1845, in 1846, and in 1847, occasioning great mortality in the latter year. In 1848, there was small-pox among the sheep; while 20 per cent. of the cattle perished in 1849

* *Vide* "Remote Cause of Epidemic Diseases."

from pleuro-pneumonia. Murrain was again general in 1851. Of late years, pleuro-pneumonia has been prevailing extensively in the North of Europe, thus showing that the cause is still in operation, and that, like the epidemic cholera, it has become a fixed and regular epizootic of the present pestilential epoch.

Cotemporaneously with these affections in the animal creation, disease or blight appeared among vegetables—attacking the potato in the first instance, but spreading, subsequently, to various other classes, and more particularly to the vine. As a natural consequence, Ireland suffered so much from the failure of the potato crop that, on the 3d of July 1847, nearly three million persons received food gratuitously from the relieving officers. From this cause, and from the disease which followed, as well as from emigration, consequent on the distress, the population of Ireland was reduced from 8,175,124 in 1841, to 6,552,385 in 1851.

In addition to the above, there is another series of phenomena, different in character, but productive of similar results—a scarcity of food. These are irregular and unfavourable seasons, or unusual atmospherical vicissitudes—phenomena that have been referred by me to one and the self-same cause. This has been more particularly apparent in this country during the last three years. Thus, there

was unusually severe frost in the autumn of 1859, which not only caused the destruction of the green fodder crops, but prevented a large breadth of wheat from being sown. This was followed by a cold and wet spring and summer, so that although the crops of grass were heavy, they could not be got in. The same weather continued during the harvest season, as rain fell for thirty-five days out of forty, while the temperature was thirteen degrees below that of the freezing point. In 1860 and 1861 also, in consequence of the severe and unseasonable weather, thousands of cattle died for want of fodder; and the price of meat was so much increased that it became a luxury to the poor. The corn crops suffered at the same time. Messrs. Horne and Watney state, in their Circular, "The English wheat crop of 1860 was, all things considered, the worst we have seen these twenty-five years. It has neither colour, strength, condition, weight, nor bulk, with some portion *blighted and mildewed.* It was deficient fully one-fourth of an average yield, which deficiency we set down at 4,000,000 quarters." The above remarks apply to barley and oats, which were affected at the same time, and to a similar extent.

These phenomena are not anomalies, or peculiar to the present period, for the same series has been observed at all epidemic periods.

Thus, in the earliest record extant, we find it

stated, that the plague of blotches and blains, murrain among the cattle, and blight in corn, all visited Egypt in close succession. The same result was observed during the prevalence of the black death of the fourteenth century; for, in consequence of disease among the cattle and of mildew in the wheat, famine was so general, that bread had to be distributed gratuitously in nearly all the large cities in Europe. At this period, in fact, to use the language of one writer, "Children died of want in their mothers' arms, and want, misery, and despair were general throughout Christendom."

Up to the present period, the pestilence in the vegetable creation has been confined, not entirely, but more particularly to the potato and the vine. Why the former root was the first to be attacked, it has been my object to show on a previous occasion; and I then remarked, that as in the animal, so in the vegetable creation, the morbific cause, whatever that may be, attacks the most susceptible classes first, the least so last, but bringing, sooner or later, every class under its malign influence.* This conclusion has been confirmed, unfortunately, to a great extent since; for, with the exception of the grain crops, nearly all other vegetables have been attacked, while even the former have not entirely escaped. In 1846

* The Cause, Prevention, and Treatment of Disease in the Potato and other Crops.

the rye in France was affected with disease, and became a total failure, cotemporaneously with a failure in the potato crop. In the same year, a disease, said to be similar to the potato blight, appeared in the wheat in Belgium; but I have not met with any other instance, in which the wheat crops have been attacked with, what may be termed, actual disease. The failure in the grain crops, hitherto observed, must be referred to atmospherical causes, or unfavourable seasons, rather than to actual disease, like that of the potato blight; which has appeared irrespective of atmospherical vicissitudes, and in the most favourable the same as in unfavourable seasons. Should this last link be added to the chain of morbid phenomena, the consequences will indeed be serious, dependant, as we now are, on other countries for two-thirds of our supply of corn.* Should a cereal blight occur in those countries from which we draw our supplies, as well as in our own, a partial famine must be the result; while, if the scarcity, instead of being general, were only partial, the price would be so enhanced as to deprive the poor man of his

* Mr. Caird, in a recent debate in the House of Commons on the subject of agricultural statistics (July 11, 1862), stated that, since the period of the establishment of free-trade, in 1847, about one-fourth of the population had, in average years, subsisted upon foreign corn. During the last year, it had amounted to *one-half* of the whole subsistence of the population of the country.

ordinary proportion of the staff of life. Hence the necessity of attempting to increase the quantity of corn grown in this country.

As, also, murrain has attacked the cattle, not only in this country but in all the North of Europe—precisely those countries from which we draw our chief supplies—another reason exists for the employment of the sewage of our towns. If the surplus sewage, or excreta, before calculated, were applied to grass lands, and in particular to the artificial grasses—the produce of which is increased to an extraordinary extent by the application of this manure—it is more than probable that we should be able to raise and feed a sufficient number of cattle to meet our own demand. If decimated by disease, we should be able to bear their loss better than now, while we might not have exhausted other supplies.

On the other hand, if we grew a larger quantity of corn than we consumed, and if we were enabled to feed a larger number of cattle than we required for our own consumption, we should be able to lay up, during years of plenty, a store for years of scarcity. As it fortunately happens, pestilence in the vegetable, like that in the animal creation, only occurs at certain periods, and sometimes at long intervals.

Thus in 1332, an epidemic period, corn was so scarce in England that a peck of wheat sold for 22*s*., an enormous sum then. In the following

year, the same quantity sold for 6*d.*! In 1491, called the "Dismal Year," there was also famine in England; as also in 1586, when human flesh was said to have been eaten. The same result was witnessed in 1588-9, termed the "Great Famine," "when," according to the phraseology of the day, "one did eat another for hunger." During the whole of this period, characterised by the prevalence of a particular disease, the Black Death, which prevailed epidemically in Europe for upwards of two centuries, there was a succession of years of scarcity and of years of plenty. The former, however, were the most numerous, continuing sometimes for two or three years in succession, although the famine was never so severe as in the instances given above. The same results have been invariably observed at all epidemic periods, of which we have any authentic information. It was the knowledge of this law, prompted by Divine wisdom, that enabled Joseph to save Egypt from the horrors of a famine.

Having thus considered the reasons—the social and political reasons—that should induce us to apply the sewage of our towns to the land, I may now proceed to discuss another and scarcely less important part of the subject. This is the value of the sewage itself, or of the *excreta* of man.

As is commonly known, a Select Committee of the House of Commons sat lately in order to inquire into

this very subject—the Utilisation of the Sewage of Towns. In moving for that Committee, Dr. Brady, in his speech, referred to the calculations that had been made of the value of the sewage of the United Kingdom, and stated that the amount varied from 15,000,000*l.* to 93,000,000*l.*—the latter being my calculation. That announcement, as a friend in the House at the moment informed me, was received with some degree of scepticism, if not ridicule. My conclusion, however, was based on the statement of Professor Playfair, that a pound of urine will produce a pound of wheat. That such is the fact there can be little doubt.

Baron Liebig states that 16 lbs. of nitrogen are sufficient for, or are contained in, 800 lbs. of wheat. This would give 115 grains for each pound. Now human urine contains 3 per cent. of nitrogen. A pound of this liquid, therefore, would contain 172 grains—57 grains more than would be required to supply the requisite proportion of nitrogen for this quantity of grain. Assuming, therefore, that the preceding conclusion was correct, viz., that a pound of urine will produce a pound of wheat, it will be easy to show that my calculation was beneath rather than over the amount.

If each individual passes 912 lbs. of urine in the course of the year, 28,000,000 persons would produce 25,536,000,000 lbs. both of urine and of wheat. This latter would be equal to 53,200,000

quarters, which, at 50*s.* a quarter, would amount to 133,000,000*l.* But the average price of wheat last year was 55*s.* Instead of 133,000,000*l.*, therefore, the sum would be 146,300,000*l.*, if we take the latter average. This is the intrinsic value of the corn that would be produced, on the supposition that all the liquid manure, furnished by the population of the United Kingdom, were applied to land sown with wheat. If applied to other crops, as barley, oats, rye, &c., the amount would necessarily be less; but this has nothing to do with my previous calculation, which was based on the assumption, that a pound of urine would produce a pound of wheat.

Having thus considered the intrinsic value of the corn that might be produced, by the application of all the *excreta* to the land, we may now pass on, in order to ascertain what is the value of the manure itself.

Taking the same calculation as before, of 912 lbs. of urine in the course of the year for each individual, 100,000 persons would give 40,714 tons of urine, and 1,221 tons of nitrogen, or about 1,500 tons of ammonia.

There is no direct method of ascertaining the value of this, as ammonia is not employed in its pure or simple state in agriculture; while there are many other ingredients in human manure which, although of less value, are still beneficial and of

considerable importance. We can do this indirectly however, by comparing the liquid manure with guano, to which it bears a very close affinity. Now in order to obtain the same amount of nitrogen from guano, as that contained in the 40,714 tons of urine, 15,000 tons would be necessary.* At 13*l.* 10*s.* a ton, the present price of guano, the amount would be 202,000*l.* This therefore will be the value of the urine for 100,000 persons. For 28,000,000, the amount would be 56,700,000*l.* This is the intrinsic value of the liquid manure, supposing that the whole were collected and applied to the land, and that agriculturists paid the same price for it as for guano. As urine contains all the other ingredients of guano, and is, therefore, equally valuable, there is no reason why they should not. If, also, the solid manure were added to the liquid, the compound would be still more valuable; for although the solid excreta contain only a small quantity of nitrogen, there are other ingredients present which are highly beneficial and necessary to plants.

We may also calculate the value of sewage in another way. In Belgium, the *excreta* are valued at 1*l.* 17*s.* per head. This, for 28 millions, would amount to 51,800,000*l.* Professor Johnson, the agricultural chemist, considers the annual value of the sewage for every 100,000 persons to be 223,000*l.*, or

* See Table F., p. 16.

62,440,000*l.* for 28 millions. This is the intrinsic value of the sewage, or what it would be worth to the agriculturists; what it would be worth commercially, or, in other words, what revenue might be obtained by its sale, is not so easily ascertained. At present, we have not sufficient data to go upon, in order to arrive at just conclusions on the subject. Much will depend on local circumstances, the elevation of the town, the facility for drainage, and the situation of the land to be irrigated—whether the sewage can be applied by gravitation, or will have to be pumped up to a reservoir by engines. These are all engineering questions, and can be best solved by engineers. There can, however, be no difficulty in this respect; the same facilities exist for conveying the sewage out of the town, as for the conveyance of the water that washes it away into the houses. Nothing more, in fact, would be necessary than to convey the pipes on to the land, instead of into a river, or the sea; or, in addition to the latter, for there must always be an outlet for superfluous water. The rest would be mere matter of detail, between those that sold and those that bought.

Although unable to say what the expenses would be, if the sewage were distributed over a large surface, an approximation sufficiently near may be obtained.

Mr. Mechi stated, at a Meeting of the Society of

Arts, that the value of the sewage of London was, in his opinion, 2*d.* per ton; and that it could be distributed, 50 miles round the metropolis, for 1*d.* per ton. This, taking the amount of sewage at 624,264,245 tons annually—Mr. Bazelgate's calculation—would produce a revenue of 5,201,986*l.*, and a clear profit of 2,600,990*l.* For 28,000,000 inhabitants, the amount would be, in the same proportions, 48,551,804*l.* and 24,275,902*l.* respectively.

The above calculation for the working expenses, although probably correct for London, is evidently too high for other and smaller towns, where the sewage, instead of being distributed fifty miles, would not have to be conveyed beyond two, three, or five. In a Prospectus lately issued for a Sewage Association at Coventry, the engineer, Mr. Shepherd, states that if reservoirs be used for the distribution of the sewage, the cost of pumping the liquid to the requisite height would not exceed *one farthing for every six tons of sewage.* If the sewage be in the same state of dilution in other towns, as in London, there would be 208 tons for each inhabitant annually. According to the calculation before made, this ought to be sufficient manure for one acre of land. The cost of pumping this quantity to the reservoir would be 9*d.*, while the expense of irrigation is set down, by the same authority, at 2*s.* 6*d.* per acre. The erection of a steam-engine,

and the cost of laying the main and branch pipes over 10,000 acres of land, have been calculated at 3*l.* per acre. Allowing 7 per cent. interest for the outlay of capital, and then adding the working expenses, as above, the whole would amount to 7*s.* 5*d.*, say 7*s.* 6*d.* per acre.

It has been before shown, that the *excreta* of a population of 28 millions would be sufficient to manure 28 million acres of land; and that the value of this quantity of manure to the farmer is 56,700,000*l.* If we deduct from this sum the working charges before specified, of 7*s.* 6*d.* per acre, amounting to 9,000,000*l.*, there would remain 47,700,000*l.* as clear profit. While, however, Mr. Mechi's calculation is probably too high, the above, on the other hand, may be too low, excepting for small towns. Perhaps we should not err much, if we were to take the mean of these calculations, and set down the working charges for the whole population at 16,000,000*l.* This would leave a clear profit to those that sold the manure of 40,700,000*l.* for the whole kingdom—supposing that all the sewage were collected and applied to the land. If only a part were employed, the profit ought to be at the same ratio.

Nothing, however, like this rate has been hitherto realized in this country, from the sale of the sewage. This, in my opinion, is to be ascribed to several causes.

In the first place, the fertilizing ingredients are too largely diluted, being not only mixed with a considerable quantity of water, to ensure their transit from the closet to the drains, from the drains to the sewers, and from the sewers to the river or the sea, but the house sewage is also mixed with the surface, or rain, water.* This is detrimental in a variety of ways.

When diluted with too large a quantity of water, the sewage cannot be applied at all seasons of the year; a considerable portion, therefore, will be unavoidably lost.

When, also, a large quantity of water is thrown on the land, only a part of it can be retained; the rest will percolate to other and deeper strata. The latter must carry with it a proportionate quantity of the soluble salts and of ammonia, for which, as before stated, water has a great affinity. The same result, in fact, will be produced as by heavy rain,

* It has been calculated by Mr. Bazelgate, that the quantity of water which passes daily out of the sewers in London is 431,000,000 gallons, of which only 95,000,000 gallons is sewage. The latter, therefore, is little more than *a fifth* of the former, or, one part sewage to 4·53 of surface water. If, also, we calculate the amount of dilution of the sewage, we shall find that to every gallon of urine there are 102 of water. This, in all probability, is a greater degree of dilution than what is desirable or necessary, but, when added to the surface water, the amount is excessive, being 460 parts water to one of urine.

after ordinary manuring. On this point, Liebig has some apposite remarks.*

In the next place, it should be remembered, it is not the matter itself which is contained in the sewers that is beneficial to plants, but the products of its decomposition. Now, although a small quantity of water favours decomposition, too much retards it; and this, there can be no doubt, is the case with the diluted sewage of our towns. It has, in fact, been shown, that the ordinary proportion of ammonia is not formed, when the urine is too largely diluted with water.

If these conclusions be correct, we can not only account for the large quantity of sewage employed in many cases, but, also, for the partial or apparent failure of this manure in others. At Rugby, with a population of 7,000, only 470 acres, it appears, are irrigated by the sewage of that town. This would be at the rate of nearly fifteen persons for each acre. But, according to the calculations before made, fifteen persons would furnish sufficient manure for fifteen acres; and 7,000 persons, therefore, ought to be able to fertilize 7,000 acres. The

* "The reason why, in certain years, the influence of the best and most plentiful manuring is scarcely perceptible," observes the Baron, "is that, during the moist and rainy springs and summers, the phosphates and other salts with alkaline bases, as also the soluble ammoniacal salts, are *entirely* or *partly* removed."

Earl of Essex also stated, at a Meeting of the Society of Arts (March 19, 1862), that he made a great mistake in supposing that the sewage of the town of Watford, with 4,000 inhabitants, would be sufficient to irrigate 200 acres; for he had since found, that the whole sewage of the town would not be sufficient for more than sixty acres. This would be at the rate of sixty-six persons to an acre! In other instances, the sewage is applied in still larger quantities. The Craigentinny meadows, comprising 325 acres, receive the sewage of about one-half of the City of Edinburgh, with a population of about 80,000. This number would give 246 persons to the acre.

On the other hand, when applied in smaller quantities—in quantities that we should, *à priori*, consider sufficient—the effect is either insignificant, or inappreciable. Mr. Campbell, of Rugby, informs us that he had employed the sewage of that town, to the extent of 45,000 gallons (204 tons) per acre; but he came to the conclusion, that the application of sewage so largely diluted with water produced very little fertilizing effect. According to previous deductions, 208 tons ought to be sufficient to fertilize one acre of land; yet a few tons less would appear to produce little or no effect.

These results prove, either that there is a great waste of the sewage; that the amount of water acts injuriously on the organic matter; or, else, that a large proportion of the fertilizing ingredients con-

tained in the sewage water, instead of being retained in the soil, passes through, with the liquid itself, into the lower strata of the earth. It is right to conclude, after the remarks just made, that all these causes are in operation, and particularly the last. This inference would appear to be confirmed by the result of the experience acquired at Edinburgh; for it is stated that 2,000 tons of sewage, applied *by the hose,* produced a greater effect than 6,000 by the shedding and open-gutter system. In the former case, as the fluid is distributed more slowly, and in showers, instead of in a stream, it would be more intimately mixed with the soil, and be more likely therefore to be retained.

To remedy these evils, the house drainage should be separated from the surface water—a proposal that has been made by me on a previous occasion. If the surface water were separated from the sewage water, or house drainage, instead of 208 tons for each individual, in the course of the year, there would only be forty-five tons—supposing that the sewage and surface water were in the same relative proportions in other towns as in London. Even this dilution would be more than is necessary or desirable, for each gallon of urine is then mixed with 102 gallons of water. But we must take it as we find it; for as long as the system of waterclosets prevails, so long will the *excreta* of the inhabitants be diluted with a considerable quantity of water.

Independently of the advantages in an agricultural

point of view, in thus separating the sewage from the surface water, there are others, of an economical or commercial character, well deserving of consideration.

In the first place, as the quantity of the sewage would only be a fifth of what it now is, the cost of conveyance will be so much less.

In the next place, it might be possible for the farmer to preserve the liquid in reservoirs, when in a more concentrated state, at those seasons in which its application to the land would be inconvenient or impossible.

In other instances, the fertilizing properties of the sewage have been destroyed in a different way. This is by the employment of deodorizers. In some cases, the agents thus employed were not injurious; in others, they were even beneficial, by preventing the escape of the more volatile ingredients, as the ammonia. But in many, perhaps the majority of, cases—for between thirty and forty patents have been taken out for different deodorizers—the employment of these agents rendered the sewage water, if not absolutely worthless, to a great extent useless for agricultural purposes. For instance, a process was employed at Leicester and at Tottenham, for precipitating the solid matter by means of lime; the clarified liquor being allowed to run away, while the precipitate was sold to the agriculturists. Although plenty of purchasers were

found at first, it became afterwards absolutely unsaleable; little or no benefit having arisen from its application. The reason is clear. Not only will the soluble salts—those not decomposed by the lime—pass away with the liquid; but the ammonia, the most valuable ingredient of all, will be driven off, or volatilized. The insoluble compound, or precipitate, could not therefore have been of any use as a fertilizer.

There are other agents, again, which act by combining with the gaseous products of decomposition, and these are the true deodorizers, for they thus prevent the odour which is given off during the process of putrefaction. As, however, it is precisely the products of putrefaction that are beneficial to plants, the action of these agents is not less injurious than the former, whenever a compound is formed that cannot be decomposed, and assimilated by plants.*

All these results—so prejudicial to agriculture, and which have hitherto proved obstacles to the

* "There is, also, another and a different reason, why sewage water does not produce the effect that we ought to expect from it. This is the fact, that a large proportion of the urine—the most valuable ingredient of all—never enters the sewers at all, and for very obvious reasons. This circumstance has been pointed out by me, on a previous occasion, and a remedy proposed for this important social and agricultural evil.†

† "Causation and Prevention of Disease," Appendix, p. 181.

employment of sewage as a manure—are to be ascribed to the prevalent theory of the day, and to the opinion, that the emanations arising from decomposing matter are injurious to the health of man.*

To the same cause we must ascribe the adoption of the main drainage scheme of London, a plan that will render the sewage of this town comparatively, or almost entirely, useless, in consequence of the great dilution of the solid matter.

Little good therefore can be expected, until these opinions are modified or removed; and it was for this express object, that I was induced to publish a work in 1859, in the hope of arresting this very scheme. That hope was a vain one, not only because the Act of Parliament had been

* The Commissioners appointed to inquire into the best mode of distributing the sewage of towns state: "that the offensive effluvia given off by animal and vegetable substanees, in a state of decay, are highly prejudieial to health, and productive of diseases of the worst forms; that deeaying human exerements, solid and liquid, are among the most injurious of such substanees; that the retention in eesspools of sueh deeaying matter beneath and around the dwellings of erowded populations is a serious nuisance, and that, for the rapid and regular removal of sueh substances, immediately after their formation, and before they ean become a source of offenee and disease, the only practieable means is *an abundant employment of water;* that is to say, the adoption of some form of water-closet."—*Preliminary Report.*

already passed, making the carrying out of this measure compulsory on the Board of Works; but, also, because my opinions were in opposition to the powers that be, and to a certain class of persons termed sanitary reformers. I also consider myself to be a sanitary reformer; but, then, I do not think, that the formation of drains and sewers is one of the measures conducive to sanitary reform. On the contrary, I believe that the system of cesspools is better, in a sanitary point of view, than the system of sewers. This has been, and will be, considered by many persons as a startling conclusion; although the medical history of London, during the past two centuries, is alone sufficient to show that cesspools cannot be promoters of disease, or drains and sewers preventives of it. Thus, in the middle of the 17th century, Plague ceased to prevail in London; while, from this period to the end of the 18th century, all diseases subsided so regularly that some—as dysentery and ague for instance—disappeared altogether.* At the former period, the deaths from dysentery were 3,000, on the average, every year; while ague was so general and fatal,

* It is commonly supposed, that the cessation of the Plague in London is to be ascribed to the Great Fire, and its purifying influence. That event, however, was merely a coincidence, not a cause; for not only had the Plague ceased in London a year previously, but the disease disappeared *at the same time* in all other parts of England, and in the majority of the towns on the

particularly in certain years when it became epidemic, that it was set down as a Plague. From 1796 to 1800, the total deaths from bowel complaints, including dysentery, were only *twenty* on the average each year! The mortality from fever also was gradually reduced, from 3,000, at the commencement of the 18th century, to 1784 at its termination.

Now it was precisely during this period, when the prevalence and fatality of all diseases decreased so rapidly, that cesspools were general and universal in London; while, from the great increase of population, the emanations from these reservoirs must have been as gradually and as regularly on the increase. At the end of this period however, or at the commencement of the 19th century, permission was given to discharge the contents of the water-closets into the sewers. Before this, the act was not only considered a nuisance, but an offence indictable at common law. The change, however, from one system to the other was not sudden, but slow and gradual. Let us mark the result.

The favourable state, before described, continued during the first quarter of the present century; but, since then, all diseases have been on the

Continent, lying in the *same parallel of latitude.* Thus, there was no Plague in Geneva after 1615, nor in Paris after 1668; although both these cities had been scourged, previously, as severely as London.

increase, and more particularly those belonging to the zymotic, or epidemic, class. Thus, the deaths from diarrhœa and dysentery, which averaged twenty only in 1800, had increased to 455 in 1840, to 2,077 in 1850, and to 3,513 in 1859. Fever, also, which produced a mortality of 905 only in 1831, has been so regularly on the increase since, that the deaths have averaged between 2,000 and 3,000, annually, up to this date.

Now it has been during this particular period, that the system of sewers and house drains has been carried out to the greatest extent; the greater portion of the 1,500 miles of the main sewers in London having been completed since 1824. In the same period also, the greatest number of house drains has been constructed, and a proportionate number of cesspools abolished. And yet it is during this very period, that all ordinary diseases have been on the increase, and that two new ones have made their appearance, in common with other parts of the country, viz., cholera and diphtheria. How then, we may ask, can cesspools be promoters, or sewers be preventives of disease? It is clear that the emanations from the former can have no influence in the production of ordinary diseases. On the contrary, we might almost be induced to ask, as one French writer has already done with respect to the epidemic cholera, Is there anything *antidotal* in such emanations to the production of

disease? That is a question that I shall not attempt to answer now; it is sufficient for my present purpose to show, that the emanations arising from the matter contained in cesspools are not injurious to the health of man.

It is equally evident, that the formation of drains and sewers exerts no influence in the prevention of disease. It has however been said, and will be, no doubt, repeated, that the present sewers are imperfect and badly constructed, so that deposits take place in them. That may be true as regards the old sewers, but the charge cannot hold good with respect to those that have been made of late years; these have not only been formed on improved principles, but they are, probably, as perfect as art can make them. Some result, therefore, ought to have been obtained during the last twenty or thirty years, if benefit can arise from such a source. Then, again, if new and more perfect sewers are to effect such wonders, how, we may ask, are we to account for the outbreak of fever at Croydon, immediately after the formation and completion of drains and sewers in that town—made, too, under the direct supervision of the late General Board of Health? And how, it may also be asked, are we to explain the irruption of cholera at Sandgate, and in Golden-square district, London, under precisely the same circumstances; none of these districts having been simi-

larly attacked before, while the visitation in the last one was the most severe that has been experienced in England ? I shall leave the advocates of drains and sewers to answer these questions.

In the meanwhile, and without waiting for these answers, we may fairly draw one conclusion on the subject; this is, that we can do what we will with our own—that is to say, collect and apply the refuse of towns in the way we deem best for the end in view. All that those who have the management of such matters will have to do is, to take care not to offend the olfactory organs of their neighbours—this being the only evil that can be produced by such emanations. Such, at least, is the conclusion at which I have arrived; and such, I believe, will be the conclusion of all other persons, after an unbiassed examination of the facts and the evidence bearing on this important subject. As soon as the authorities and the public have arrived at the same conclusion, agriculturists will be enabled to ascertain what is the best manner of collecting the sewage, and of applying it to the land; as, also, the amount of dilution necessary to obtain the desired results. This, in my opinion, is all that is necessary in order to render the application of sewage water successful, and productive of all those great results that have been before detailed.

In the preceding pages, the application of sewage

water has been alone considered, inasmuch as it is precisely this which is now wasted and thrown into the sea, as entirely useless and without value. In other instances, however, as in villages and in the majority of small towns, instead of the system of sewers, that of cesspools exists. In large towns, the former is not only the most convenient, and the most satisfactory, way of getting rid of the *excreta* of the inhabitants, but it is also the most economical, and hence its general adoption. The latter system however is not only the best, in my opinion, in a sanitary point of view, but in an agricultural one also, if properly carried out. This is not the place to discuss the sanitary part of the question; but the advantages, in an agricultural point of view, are the following.

If retained in reservoirs, the manure could be employed at the most convenient time, and in the fittest season. When obtained in this concentrated state, the farmer could dilute it to that degree which subsequent experience may prove to be the best, for the end in view; and according to the season, or the nature of the crop. It is quite clear, that the amount of dilution ought not to be the same in all seasons—in wet and in dry seasons or years—and to every variety of crop—to the grain crops, for instance, and to grass land. In addition to these advantages, all the evils attendant on the excessive dilution of the sewage, and before detailed, would

thus be avoided. It would only be necessary to take care that no nuisance be created, by the escape of emanations from the reservoirs into the surrounding air. That no injury would or could arise to the health of the inhabitants or workmen, it has been my object to show on a previous occasion.*

That the *excreta* of the inhabitants, even of a large town, can be collected, retained, and distributed in a concentrated state, without creating any nuisance, there can be no doubt. More than this, the very means taken, to prevent a nuisance, would be precisely those best fitted to render the matter more valuable to the farmer—provided that the proper agents were resorted to. Not only may the ammonia be fixed, and all other emanations be rendered innocuous or inoffensive; but the compounds thus formed would then be retained in the soil, ready to be assimilated by the plants, instead of being dissipated, in a gaseous form, into the surrounding air.

These reservoirs, however, ought to be emptied as frequently as possible; as soon, in fact, as the land is ready to receive their contents. The contrary plan is too generally pursued; not only are they left without being emptied for months, but for years also; and, as no agents are employed to

* *Vide* "Causation and Prevention of Disease."

fix the ammonia, the manure becomes deprived of a portion of its most valuable ingredients.*

In order that this operation may be effected with more ease, and with less annoyance to the inhabitants, these reservoirs should be placed in the centre of the streets, instead of under the houses, or in the back yards. One reservoir, also, could be made to communicate with several houses. So, again, instead of these reservoirs being in the streets, they might be placed outside the town—if it be not too large or too populous—while the contents could be carried by pipes to other reservoirs, to be thence distributed on the land. These, however, are mere matters of detail, which time and experience will point out and settle in a more satisfactory manner than can be done at present, or by the writer of these remarks. My object has simply been to point out the great value of the *excreta* of man in a social, financial, and agricultural point of view; the practical part of the question, or the carrying out of the necessary measures to realize the benefits before detailed, must be left to others—to the Government, or to the authorities in the towns, and to the agriculturists.

* When this method is resorted to, instead of the ordinary cart, a pneumatic one should be employed, by which means the operation is performed almost instantaneously, and without any annoyance.

CONCLUDING REMARKS.

It has been already shown, that every individual—poor as well as rich, low as well as high—throws away, every day of his life, two pounds and a-half of wheat with his *excreta;* or, what is the same thing, that which might produce this quantity of corn. This would amount to 912 lbs. in the course of the year, or rather less than two quarters. The result, actually, is much greater, for when this quantity of manure is applied to an acre of land, the produce, as before mentioned, is 53 bushels, or rather over $6\frac{1}{2}$ quarters. Not that the manure furnishes the nitrogen for this additional quantity of corn; this is derived from the atmosphere—one of the sources from which plants draw their supply of this necessary element. As such, it may be thought, that the only advantage gained by the application of the manure would be the 912 lbs. over and above what might otherwise have been obtained. That may be the case for once, or for one year; but then the crop, thus grown, would be deficient in gluten or nourishing properties; while, if corn continued to be sown on the same land, for a series of years, it would become barren. The cause is probably this. Unless a certain amount of nitrogen be present in the soil, the young plant, we may presume, cannot grow, even supposing that the seed is enabled to germinate. It will

not, therefore, arrive at that stage which would enable it to draw an additional supply of nitrogen from the atmosphere above. In the same way, an infant is unable to take solid food, until it has fed for some time on its mother's milk or a similar compound, and has thus acquired a certain amount of strength. We may therefore say in practice, although not in theory, that the *excreta* of each individual will produce, if applied to land sown with wheat, $6\frac{1}{2}$ quarters of corn. According to the present price of wheat, this quantity, together with the straw, would produce 26*l.* Suppose we set down 5*l.* for seed, rent of land, &c., which is more than sufficient, if waste land be used; there would then remain 21*l.* as clear profit, independently of the cost of labour. If, however, the individual who rented this land were enabled to cultivate it, at the same time, he might realize the whole of this sum every year. Reverting to the subject alluded to in the Preface, it is fair to ask, Would such a resource be of any avail to the unemployed operatives in Lancashire? In one sense it would not, for they could obtain no return from the land until the end of a year. In the meantime they must live, so that unless they had a reserved fund of their own, such a mode of employment would be useless to them, dependant as the majority now are on public aid for support. But, although unable to furnish the funds, they can find the labour. The question

therefore arises whether, as there are so many labourers standing idle in the market-place, other individuals could not be found to furnish the requisite capital; and whether this would not be a better plan than any other, for affording relief to our distressed fellow-countrymen? It would be, at all events, a more agreeable mode than that of breaking stones on the road; while it might also be a more independent plan of affording aid to this noble and deserving class of sufferers.

I do not pretend to point out the manner in which this suggestion should be carried out—whether by the authorities in the different towns, or by means of a Company. I would merely observe that, while the columns of the daily papers are filled, at the present moment, with a prospectus for an Irrigation Company in Spain; and while a similar Company has just been formed in Italy, both composed principally of Englishmen, there ought not to be—there would not be, I should hope—any lack either of philanthropy or of funds for a similar undertaking in England. Setting aside the philanthropic motives—the desire to aid a class of men who, by their noble conduct, have gained the sympathy and admiration of every man in the country—the pecuniary advantages would be much greater; as much as the difference in the value of sewage water and of ordinary water, in an agricultural point of view.

The formation of a Company would not be necessary in all cases, and in all towns. If the operative had a piece of land allotted to him, and if he were paid for his daily labour, he could himself furnish the requisite manure for an acre of land; and, if he had a family, for several acres, according to their number and age. It would only be necessary to save the *slops* of the house every day, and to throw them on the land; diluted to a greater or less extent, according to the season of the year, and the nature of the crop, as, also, the state of the land.

By a reference to the table before given, it may be seen that there are 18,000,000 acres of uncultivated land in the United Kingdom. What proportion of these is waste land, or land capable of cultivation, if manured in the manner referred to, it would be difficult to say, no calculation, that I am aware of, having been made on the subject.* If we were to conclude that two-thirds, or

* This has been done for Ireland, and is as follows:—

	Per cent.
Cultivated land and pasture	69·34
Uncultivated	24·14
Water	3·03
Towns	2·02
Plantations	1·47
Total	100·00

In England, the quantity of land occupied by towns and

12,000,000 acres, are waste land, capable of more or less cultivation, we should not probably err greatly. While, therefore, we have this number of uncultivated acres, and the means of rendering them fertile at the cost of labour only, it will be a disgrace on the science and philanthropy of the age to allow a single individual to remain idle, or to want a loaf of bread.

Independently of the advantages that would follow at the moment, by the carrying out of the above proposal, it might have, in my opinion, another and a more permanent one. If, by directing the attention of the operative to this source of labour, he should hereafter become fond of agricultural pursuits, it might be the means of inaugurating a principle that I consider to be a sound one, applicable to all times and to all circumstances; this is, that the operatives should combine agricultural with manufacturing labour. Modern political economists, and the advocates of the division of labour, may possibly start at such a proposition ; but a little reflection and consideration of the subject will, perhaps, convince them that it is

roads would be much greater than in Ireland. In Scotland, also, there would be less waste land capable of cultivation, in consequence of the mountainous nature of the country. On these accounts, we must make a greater deduction from the number of uncultivated acres, before specified, which included all land not cultivated or in pasture.

not a very irrational one. On the contrary, I hope to be able to show, in a very few words, that the principle, when capable of adoption, would be a sound and economical one, both for the masters and the operatives.

The employment of the majority of the workmen in the cotton mills, and in many other manufactures, is entirely of a sedentary nature; while, from the number of hours that they are employed, the labour naturally becomes irksome and monotonous. Not only is such work depressing to the mind, but it is injurious to the body; as well on account of its sedentary nature, as from its continuance and uniformity.* We all know the exhaustion produced by the continued, and even short, action of the muscles, when that action is without intermission. This is often illustrated by a very familiar experiment. If a man, with a weight in his hand, holds his arm out steadily in one position, he will find himself unable to continue this for more than a few minutes—sometimes only a few seconds, according to the weight of the object. Let him vary the position however, from time to time, and he will be enabled to carry it for some hours. It is also well known to those persons who have been

* The physical deterioration of the inhabitants of Lancashire has been referred to previously. The above circumstances must be considered as one of the causes of this deterioration, as well as those then mentioned.

accustomed to ride or drive horses in hilly and level countries, that they will travel farther in the former, and with more spirit, than in the latter. The reason is sufficiently apparent. In going up and down hill, the muscles will be in a different position to what they were on the level road, and hence the relief to the animal; although, when in harness, he may have a heavy drag behind him.

The operative can seldom have this change: there may be intermission, but it is, in general, the same set of muscles that is kept in action during the whole day, and day by day. To give him relief, he must have change of employment. There is no other way, that I am aware of, by which this can be accomplished, unless by making him an agricultural labourer at the same time, or, in other words, his own gardener. What I propose is, that every operative should have a piece of ground to till, so as to give him exercise and employment for one or two hours every day. In addition to the muscular change and muscular energy, already pointed out, there is another advantage that would be gained by the adoption of such a plan. This is the inhalation of a different, and, what is termed, a purer atmosphere, or one containing more oxygen. We all know the exhilarating effect of this agent, and its influence in promoting the circulation of the blood, as well as producing increased muscular energy. A man

therefore, who took this additional quantity of exercise, would be better fitted than before to undergo his other daily, and more important, work. But then, he would not have so much time to perform it in—a very important consideration in an economical and political point of view.

There are two parties interested in the economy of the measure—the masters and the operatives—whose interests, it may be supposed, are not identical in this matter. This, however, I hope to show is the case.

It may be considered that men, thus engaged in other labours for one or two hours in the day, might come to their work tired and wearied; and that they might be taken away from their regular and more important employ for too long a time, to suit the convenience of their masters.

With respect to the first of these objections, it is not only probable but certain, that the operative, instead of coming fatigued, would return to the factory better fitted to go through his daily work, than if he had not taken this previous exercise. We have proof of the truth of this conclusion every day, and among all classes—with all the amateur gardeners in the kingdom, and their name is Legion. The banker, the merchant, the lawyer, or the citizen, does not find that he goes through his daily work the worse, because he had an hour or two hours' work in his garden previously; on

the contrary, it is precisely this which enables him to sustain the drudgery and toil of his profession, with spirit and energy. It is probable, therefore, that the operative would not only go through his daily labour, with more alacrity and cheerfulness; but that he might also do as much work in *eight* hours, as he now does in ten. If so, the plan would be advantageous and economical to the manufacturer, as well as to the operative. Should the diminution of time, however, be a loss to the manufacturer, by causing diminished production, he would only have to engage additional workmen, of whom there is no deficiency in this country.

The above are not the only advantages that would follow the carrying out of such a principle. As the cultivation is not always continuous, and need only be carried on at particular times and seasons, the operative might thus have a something to fall back upon in times of sickness and scarcity. It would also be a resource to him during *crises* like the present one. Unexpected as the failure in the cotton supply has been, we must yet remember that the same result may occur in future, and from a variety of causes. It becomes, therefore, a serious subject of inquiry, not only to the operative and to the manufacturer, but to the statesman and to the philanthropist, to ascertain how these possible and probable evils—these commercial epidemics—are to be prevented and treated

in future. The only way, as it appears to me, is by making the operative, to a certain extent, an agricultural as well as a mechanical labourer. It is not to be supposed that employment can be found for 200,000 or 300,000 persons, thrown out of employ; nor can the State or the country afford to keep them in comparative idleness, for any great length of time. Were there only a few thousand persons affected by the change, it would be a different matter; but when we know that there are between four and five millions, the question becomes a most momentous and vital one to the manufacturing interests, and to the nation at large. As these facts are now, unfortunately, so well-known, and are exciting general attention and discussion, it must be unnecessary to enter into any further arguments on this part of the subject: my object, at the present moment, has simply been to throw out the suggestion, not to enter into details of the measure.

There is one other point that I wish to allude to, before closing these remarks; this is, that the plan, if carried out, would be beneficial, not only in a social and economical point of view, but in a moral one also. By giving the operative some amusing employment in his leisure hours, you stand the chance of taking him from the gin-palace and the public-house; where the proceeds of his labour are so frequently squandered, instead of being reserved for the subsistence and comfort of himself and of

his family. When possessed of a piece of land, he may cultivate, in addition to corn, a few flowers in the nooks and corners, to adorn his humble dwelling; while he might, when thus engaged, acquire a taste for the beautiful productions of nature. A lover of flowers will seldom be, can hardly be, a bad or a depraved man; for not only does the contemplation of Nature's works elevate the mind, but it raises the thoughts, at the same time, from Nature up to Nature's God. With the elevation of his mind, he will himself be raised, if not in the scale of society, at least in the scale of humanity.

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